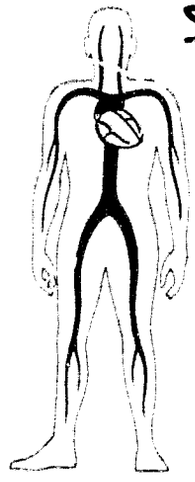
CR-160608

SQT

MSC-18783



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TECHNOLOGY INCORPORATED
LIFE SCIENCES DIVISION

FINAL REPORT

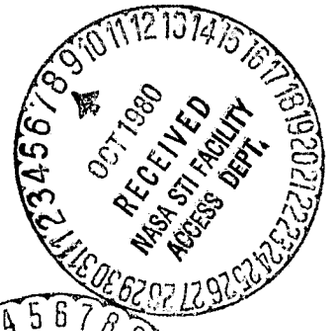
ON THE

CARDIOPULMONARY DATA ACQUISITION SYSTEM

VERSION 2.0

VOLUME 1

USER'S GUIDE



Prepared for the NASA Johnson Space Center
Cardiovascular Research Laboratory

December 17, 1979

P. O. BOX 58827 • HOUSTON, TEXAS 77058

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Contract NAS9-14[illegible]
Project 0160-20

TECHNOLOGY INCORPORATED
LIFE SCIENCES DIVISION
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APPROVAL SHEET

FOR

THE CARDIOPULMONARY DATA ACQUISITION SYSTEM

(VERSION 2.0)

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ABSTRACT

The Cardiopulmonary Data Acquisition System (CDAS) is a computerized method of both collecting and analyzing physiological data on subjects during a treadmill or ergometer stress test in the clinic. The real time acquisition of the physiological data, such as, heart rate, blood pressure, work load, and respiratory gases is accomplished by an LSI-11 microcomputer which displays this data on a hard copy terminal. The data is also concurrently stored on a mass storage device (floppy disk). Immediately following or anytime after the test period a selectable number of copies of the plots or minute reports can be reproduced at the terminal. The data stored on the floppy disk can be edited by the user to produce additional reports and plots which do not contain spurious data or loss of signal.

CDAS DEVELOPMENT PERSONNEL

William Crosier - Overall system design (hardware and sofware), programming, documentation.

Charles Mann - Original project leader, general programming, documentation.

Roy Reed - Chief programmer for original version, documentation.

Abhijit Gadgil - General programming.

Gordan Rutt - Original plot routine programming.

Dorothy Stephens - Pretest routine programming.

John Donaldson - Hardware fabrication, interfacing, and checkout.

Sally Grill - Typing for documentation.

Diane Wesley - Typing for documentation.

Kay Elton - Graphics for documentation.

Benjy Ashley - Typing for documentation

Table of Contents

OVERVIEW OF THE CARDIOPULMONARY DATA ACQUISITION SYSTEM

Purpose and Philosophy

The Cardiopulmonary Data Acquisition System (CDAS) is a physiological data collection and display system for a cardiovascular stress test which uses either a treadmill or an ergometer. As a subject is going through the flexible test protocol, CDAS samples the cardiovascular parameters of heart rate and blood pressure,the pulmonary parameters of exhalation volume and gas concentrations, and the exercise parameters of ergometer workload or treadmill speed and elevation. This primary information and secondary information derived from the primary data are displayed on a Decwriter hardcopy terminal every thirty seconds during the test.

The microcomputer based CDAS replaces the operation on the NOVA minicomputers in building 37 which replaced the large Sigma 3 computer in building 7. The NOVA based operation uses the computer after the test to produce a minute summary of the test data from an analog tape recording made in the lab during a test. The laboratory test equipment had no direct interaction with the NOVA and no data was processed in real time. Plots and reports were produced only after the analog tape was carried to the NOVA room and two generations of digital tapes had been processed. The real time CDAS operation will speed up the display of the test information and greatly reduce the time required of an operator.

CDAS improves upon the data collection facility of the NOVA system, but it does not encompass all of the features which were evolving on the relatively self-sufficient Sigma 3. CDAS has not been designed as a data base management system to store and retrieve information on test subjects so that analyses can be performed on the data. Its only intent is to facilitate the collection of

the real time data. The data base requirement will continue to be handled by the separate Medical Information Computer System (MEDICS) as it has with the previous data collection system.

Hardware Configuration

The CDAS project uses most of the laboratory equipment which has been used in the stress tests in the past. New interfaces and electronics have been added to all of the laboratory equipment to enable the computer to control the equipment or exchange information with it. The laboratory equipment consists of a spirometer to measure the volume of air exhaled by the subject, a mass spectrometer to measure the concentration of oxygen, nitrogen, and carbon dioxide in the expired air, a blood pressure measurement system (BPMS) to determine systolic and dystolic pressure, a cardiotachometer for collecting the sybject's instantaneous heart rate, and an ergometer or a treadmill for exercising the subject. In addition, the CDAS project has implemented an LSI-11 microcomputer and Decwriter hard copy terminal by Digital Equipment Corporation and a dual floppy disk drive by Data Systems. The operation of the equipment is controlled by the pushbuttons of a specially designed control panel. The block diagram of Figure 1 shows the major equipment groups and how the data travels from the exercise lab equipment through the system and finally into MEDICS.

Software Description

All of the CDAS software is stored on the floppy disk which is inserted into the "DX0:" slot of the disk drive. There are four major groups of software: (1) the operating system which consists of the monitor and the peripheral

HARDWARE CONFIGURATION OF CDAS

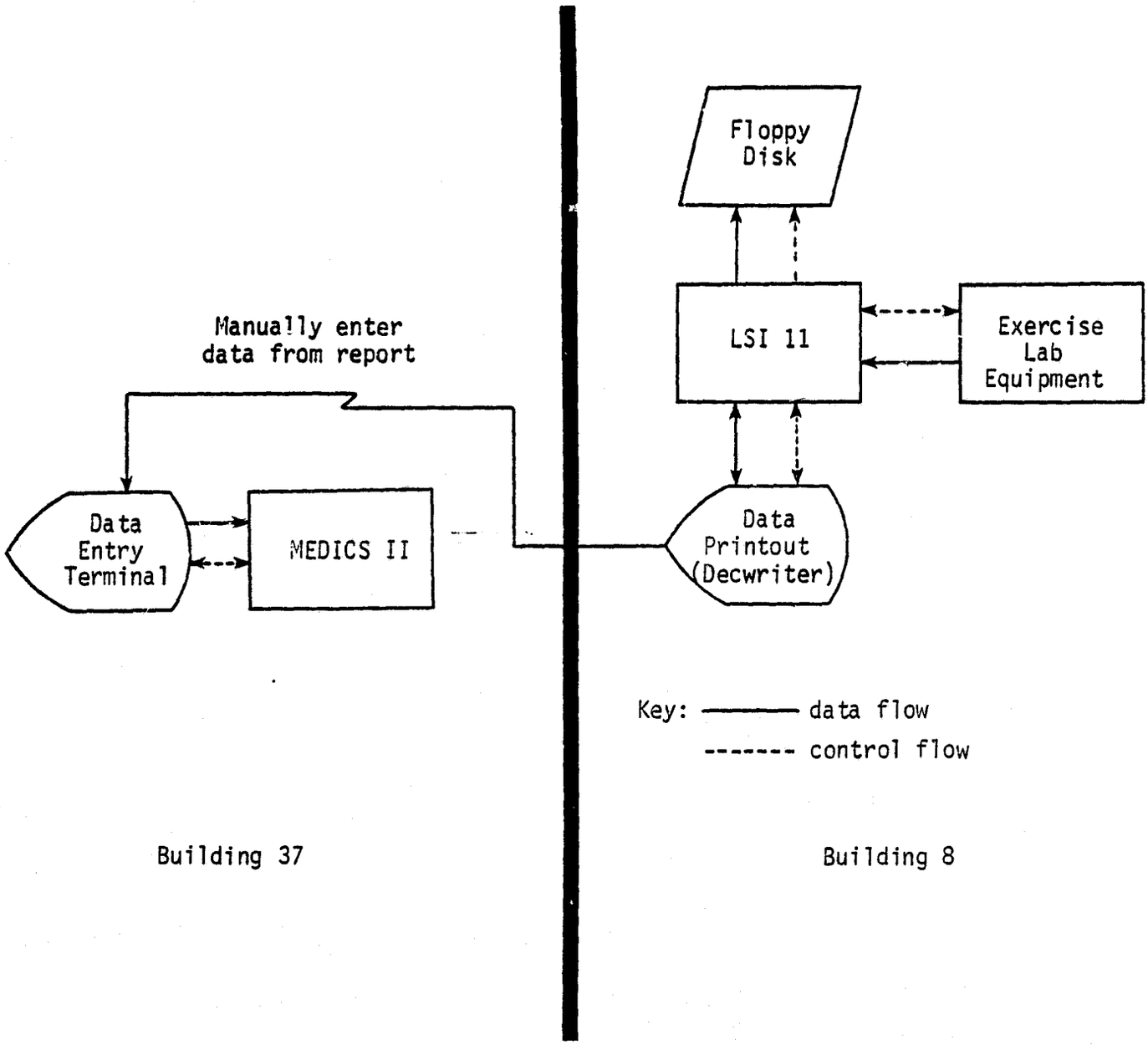

Figure 1

interchange program (PIP) which was purchased from the Digital Equipment Corporation to help the application programs to execute properly, (2) the pretest program that creates a file on the other floppy disk and stores subject identification information for use later during the test, (3) the stress-test routines which are active in collecting, storing, and displaying the physiological data during the test, and (4) the post-test programs which are used to edit the subject file to correct spurious data, print minute summaries, and plot the data collected during the test.

The data collected during the stress testing is stored by subject on the floppy disk inserted into the "DX1:" slot of the disk drive. The CDAS programs and the subject data files are on separate floppy disks. The CDAS program disk is not changed in any way during the operation of the system. However, the subject data disk will become filled when almost eighty subject files are stored on it. At that point old subject files should be deleted or a new floppy disk should be used. The operator's manual section of this report should be consulted for a detailed explanation of this procedure.

System Operation

The operating procedure under the CDAS program starts with the creation of the subject data file using the pretest question program, PRETEST. The program stores the answers in the file to several questions that it asks the operator. Some of the questions are for subject and test identification which will be displayed with the physiological data collected during the test. The rest of the questions are concerned with information that is required to collect and transform the physiological test data by a series of calculations into

meaningful results. These include such things as target heart rates for the ergometer stages, ambient temperature and pressure, and the weight and age of the subject.

Once the data file for the test subject has been created, the main test program, STRESS, can be initiated. When the program starts executing, the "CAL" pushbutton light on the control panel is illuminated, indicating that the calibration of the laboratory equipment is the only allowable choice of operations at this time. When it is pressed, the program automatically calibrates the analog signals coming from all of the equipment used to collect the physiological data. The range over which the data is sampled is assumed to be linear, so the calibration routine determines a slope and intercept for each of the signals. This information is stored in the subject data file for use by other routines that convert the raw analog signals into meaningful units of measurement. The calibration routine provides a quick and easy way to scale the analog signals from the test equipment and provide accurate readings even though the signals may vary slightly from day to day. Appendix B shows the report printed by the calibration routine. By studying this report, the operator can determine if the equipment is operating properly so the next step in the CDAS operation can be taken or if there is trouble with the equipment and adjustments must be made.

After a successful calibration several options are open to the operator. The program can be terminated (later in the day the stress test can be run without recalibrating, although this is not advisable), another calibration can be

performed, or the operator can move on to the exercise section or forced vital capacity section of the program.

If a forced vital capacity measurement is to be taken on the subject, it is best to do it after calibration and before the exercise. The most accurate measurement can be taken at that time. If it is taken after the exercise portion of the stress test, the subject will tend to be winded and his diaphram and lungs will be fatigued. However, CDAS will allow the operator to take a forced vital capacity measurement any time the "FVC" pushbutton is illuminated. Instructions on how to perform a forced vital capacity measurement are given in the operator's manual in the next section of this report. Actually the operator may not be too concerned with the accuracy of the measurement since it is to be used as a quick screen to identify individuals who may have some lung disease. If this measurement indicates something of that nature, other equipment does exist which should be used to thoroughly investigate the possible problem.

The heart of the test is the exercise portion of the operation which consists of a rest phase, a work phase, and a recovery phase. The rest phase is set up to automatically collect and display all the physiological data except for the workload parameters for a ten minute period. At the end of this period CDAS pauses and waits for the operator to press a pushbutton to initiate the actual work phase. If the operator wants to shorten the rest period or even restart the rest period, it can easily be done by pressing the appropriate pushbuttons on the control panel as explained in the operator's manual. The work phase collects the data on the subject as he is stressed on either the ergometer or the treadmill. If the ergometer is selected, a program is used

which regulates the workload so that the subject's heart is beating at a specified rate by the end of each of the four stages in the ergometer stress protocol. After the stress test the operator advances the program to the recovery phase for the final data collection. The total time in the three sections (rest, work, and recovery) combined cannot exceed one hour. The subject file cannot hold anymore data than that.

Throughout the entire exercise portion of CDAS the primary physiological data collected and the values derived from this data are normalized to a minute and displayed on the hardcopy terminal every thirty seconds. Each phase of the test is identified by a title of Rest, Exercise or Recovery. The operator monitoring this display will have sufficient real time information to understand the current condition of the subject so that quick decisions can be made if something appears to be out of line.

After the test has been concluded, any number of copies of the one minute summary report can be printed on the hard copy terminal by using the REPORT program. REPORT reads the information stored in the subject data file and prints it out in the same format as the real time thirty second report printed during the stress test. However, the one minute summary report prints a full minute of data on each line while the real time report prints thirty seconds of data to a line.

If any of the data has been missed or spurious data recorded into the data file, the REPORT program can also be used to correct this problem. It contains an editor which can be used to modify any of the primary data collected during

the stress test. The secondary data cannot be modified; it will be derived from the new primary data when the one minute summary is printed. The information on the final one minute summary should be used to manually enter the records into the MEDICS data base.

Also the PLOT program can be used to graphically display the information stored in the subject data file. The standard plots are blood pressure vs. time and heart rate vs. time on the first page and volume of oxygen and carbon dioxide vs. time and workload vs. time for the ergometer on the second page. If the treadmill is used the workload graph is replaced by a graph of oxygen in units of ml/kg-min vs. time. Other graphs are also available if desired. An example of the plots can be found in the appendix of this report.

Alternate Operation

During a stress test the data will be recorded on an analog tape recorder as it is sent to the LSI. If the LSI fails during an ergometer test, the operator must flip the workload control switch from "computer control" to "manual control". If a treadmill test is in progress during a computer failure, the operator does not have to do anything special. All of the data will be recorded on the analog tape. Each test performed until the computer is repaired, will have its data recorded on an analog tape.

After the LSI is functional again, the user must use PRETEST to create a new subject data file and indicate in a pretest question that the data will be from the analog tape rather than from the live signals. The computer will

accept the data recorded on the analog tape instead of data from the laboratory equipment when the "TAPE" switch is thrown. The data recorded on the floppy disk and printed in the reports and plots will look the same as if it had originally been recorded directly from the laboratory equipment.

Future Expansion

The first CDAS has been designated as version 1.0. In order to maintain the proper documentation for the system in use, a version number will be associated with any changes made. The version number will appear on all the documentation and the software. The version number consists of two numbers separated by a decimal point. The number to the left of the decimal point indicates the major revisions, and the number to the right indicates the minor corrections. Minor corrections include slight adjustments and improvements in the existing hardware and software to bring them up to the specifications in the design documents. Major revisions include hardware or software changes that affect the interface with the operator or additional features which require more equipment and/or software.

In the future the control panel will probably be improved to make it simpler to operate and easier to understand. This would be a major revision which would increment the number to the left of the decimal point in the CDAS version number. However, when the operating procedure in the lab changes from manual entry of test results into the MEDICS data base to automatic entry from the floppy disk files created by CDAS, a major revision number will not be assigned because it will not require a change in CDAS. At that time the floppy disks

containing the subject data files from CDAS would be carried over to the MEDICS computer and read in from the MEDICS floppy disk drives. Therefore, only the MEDICS system would have to have new software to read the CDAS floppy disk files.

The current version 2.0 of CDAS is a comprehensive real time data collection and display system which adequately meets the present needs for the cardiovascular stress testing in the Johnson Space Center Clinic. The future needs of both the clinic and other potential users have been considered in the design so that only a minimum of modifications should be required; and those that are made should be easily implemented making the Cardiopulmonary Data Acquisition System a highly useful tool for years to come.

USER'S MANUAL

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GENERAL INFORMATION

The intent of this discussion is to provide the basic knowledge needed in the application of the CDAS programs. Only the information needed to execute each program is discussed. This normally only involves user/computer interaction via the system console and the CDAS control panel; however, other aspects such as booting the system and loading and unloading disk are discussed. The discussion of all programs should be read thoroughly before using them.

The CDAS programs covered are:

1. PIP - Peripheral Interchange Program. This DEC - supplied program allows files or entire floppy disks to be deleted or copied.
2. PRETEST - allows the user to enter into the computer the subject's pretest information.
3. STRESS - allows the user to enter specific commands into the computer via the CDAS control panel to collect and display real-time test data.
4. REPORT - allows the user to generate any number of one minute summary reports. Also, gives the user the capacity to edit the average one minute data.
5. PLOT - allows the user to generate a number of plots of specified data.
6. EDICON - allows the user to modify the reference constants used in calibrating the system.

Throughout this section several standards are used. They are:

1. The symbol '< CR >' refers to a carriage return typed by the user.
2. All user input is underlined.
3. The symbols "." or "*" preceeding each user input via the system console terminal indicates that the computer is ready for a command.
4. The CDAS control panel can accept commands from only those pushbuttons which are "ON" (Lit).

5. Flickering lights on the CDAS control panel indicate that the labeled function is currently executing.

Prior to executing any programs the computer must be powered ON and booted (started). Also, the CDAS disk must be loaded into DX0: of the disk drive unit (the left unit). Subject data disk must be mounted in DX1: (the right unit).

Use the Following Procedure:

A. Prepare equipment and instruments for operation.

1. Turn on the power for the computer, terminal, and other necessary equipment. Verify that all power indicator lights are illuminated, and that the terminal is on line.

2. Place the CDAS floppy and Patient file floppy into their appropriate disk drive unit.

   (a) DX0: (left-hand slot) CDAS floppy

   (b) DX1: (right-hand slot) Patient file floppy

   The floppy disks must be inserted so that the label side is to the left. The end farthest from the label is inserted first. After inserting each floppy, slide the door on the diskette drive to close it. Be sure to follow the storage and handling instructions on the floppy storage envelopes.

3. The computer responds by printing the message

   RT-11SJ V02C-02

B. In response to this message the user must type in:

1. DAT DD-MMM-YY<CR>

   Where: DD is the current day

   MMM is the month

   YY is the year

   Example: DAT 19-OCT-78<CR>

2. TIM HH:MM:SS<CR>

Where: HH is the hour 1-24 (greater than 12 if 1 pm or later)

MM is the minute

SS is the second

Example: TIM 13:32:48<CR>

Note: The time must be sychronized with the Time Code Generator-Reader. The computer internal clock is set to the specified time and is started when the return key is pressed.

The date should always be entered as above whenever the computer is booted - when it is first powered up after being turned off, or when it has been rebooted by pushing the front panel "RUN" switch. The date is used by the computer whenever a data file is stored on a floppy disk and when various reports are printed out.

The time of day should be entered whenever a stress test is to be run, because the computer samples the signals from the automatic blood pressure system at a particular point in its cycle. It does this by sampling blood pressures only during the 55th second of each minute. Therefore, the computer internal clock should be synchronized with the time code generator-reader, and the automatic blood pressure system should always be started at about 15 seconds after the minute so that it will have completed its cycle by the 55th second. Otherwise, erroneous blood pressure will be recorded.

In order to run a stress test, the following programs should be run after the computer has been started:

(1) First run PRETEST. This can be done immediately prior to the test, or earlier (even the previous day) if all the necessary information is available. PRETEST can also be run separately for several different tests, using different patient filenames for each, even before the first test. However, since information such as the subject's weight usually

is not available until just before each test, it may be desirable to input each subject's data in PRETEST immediately before the test, although it is not required by the programs.

(2) Next, run STRESS to collect data during the actual test.

(3) At any time after the test is over (even the next week), REPORT can can be run to edit the test data, if necessary, and then get copies of the one-minute summary report. The editing should always be done before summary reports or plots are obtained. In case a summary report or plot is printed before editing is done, the earlier copies should be thrown away since they may not have any indication that they contain erroneous data. The "report date" printed on the summary reports and plots can also be used as a guide to tell if the data was printed before or after the date that it was edited.

(4) PLOT can next be run, if desired, to generated plots of the test data. It always plots only the latest available data. In other words, if data has been edited with the REPORT program before running PLOT, then the plots will contain the edited, rather than the original, test data.

(5) PIP can be run anytime another program is not executing in order to accomplish a number of tasks. For instance, it should be used regularly to get listings of the data files on the patient data floppies and to make backup copies of them.

(6) EDICON should be run only when it is necessary to change the calibration reference constants. For example, this should be done if you install a new cylinder of calibration gas for the mass spectrometer, so that the computer programs can use the correct gas concentrations in the calculations.

After running whatever programs are needed, the computer should be shut down in the following sequence:

(1) First, push the button beside each slot of the floppy disk drive in order to release the floppies. This should be done even if they are going to be left in the disk drives after powering down the system (although this is not recommended).

(2) Next, remove the floppy disks from the disk drive and carefully store each in its special protective envelope. Be sure to put them in a safe place and handle them according to the instructions on their envelopes.

(3) Finally, turn power off for the computer system, and shut off any compressed gas valves that may be on, etc.

PIP

(Peripheral Interchange Program)

This is a DEC - supplied program which is used to perform file maintenance tasks. It should be used regularly to do such things as obtaining listings of the directory information for the patient data floppies, and making backup copies of files. For more detailed information about using PIP, refer to the DEC RT-11 System Reference Manual.

To start PIP, type:

.RUN PIP<CR> (user imput is underlined) Then when PIP is ready to accept one of its commands, it will type an asterisk (*). When the user is finished using PIP, the program can be terminated by typing Control-C (CNTRL-C). The control key works like the shift key. Note that while PIP is running, it will not accept anything other than PIP commands (discussed below). Therefore, if you try to run another program, such as PRETEST, by typing RUN PRETEST<CR>, then PIP will not be able to recognize this and will type an error message. Control - C must be used to terminate PIP before using other, non-PIP, commands.

The more commonly used PIP commands are listed below. They may be used in any order, whenever PIP has typed a "*" to let you know it is ready.

A. Initializing a Floppy Disk

This is done either:

1. When you want to use a new floppy disk which has never been used before, or
2. When a floppy has only old data on it which is of no value, and you want to remove the old information so that the floppy can be used again. Generally, this is not recommended, since an old floppy, that has been used for a long enough period of

time to fill it up with patient data files, may be somewhat worn and unreliable.

To initialize a floppy, run PIP, put the floppy to be initialized in the right hand disk slot and type:

*DX1:/Z<CR>

where <CR> means carriage return, as usual.

PIP will respond with:

DX1:/Z ARE YOU SURE?

Be absolutely sure that you have not mistakenly typed DX0 instead of DX1 (otherwise your system floppy would be deleted), and that you have not put a floppy containing any useful data in DX1.

Type: Y<CR>

and then PIP will zero out (initialize) the floppy inserted in DX1: (the right hand slot). This should only take a few seconds or less, and then PIP will type an "*" again to let you know it is ready for another command.

This command causes the directory on the floppy in DX1 to be zeroed out. This effectively erases the information on it. Although it is sometimes possible to retrieve information from a floppy after it has had its directory zeroed, it is quite difficult and generally not practical.

B. Getting a Floppy Directory (Contents) Listing

To get a formatted summary of what is stored on a floppy disk, type the following while in PIP:

*DX1:/E/W<CR>

This causes a listing of the file names, their creation dates, and other information concerning such things as their physical locations on the floppy in DX1 to be printed on the terminal. All patient

filenames have .DAT appended to the filename which the user entered in PRETEST. The date printed is the date the file was created or last modified (by STRESS or REPORT), whichever is last. It can thus be used as a guide in determining when a file was last edited with REPORT.

A listing of each patient data floppy, using the /E/W PIP command, should be obtained regularly if data files are being created on it. This should preferably be done at the end of each day in which tests were run. The latest listing for each floppy should be saved in order to help keep track of what information is on each floppy, and also because it can sometimes be useful in retrieving files which have accidentally been deleted but not overwritten. Each such listing should be labeled to correspond with the particular floppy it summarizes, and then taped on the special protective envelope for that floppy. Alternatively, the listings can be kept in a notebook.

If you need to see if a particular file is on a floppy without getting a complete listing, run PIP, put the floppy in DX1, and type:

*DX1:name.DAT/L/W<CR>

where "name" is the filename that you used in PRETEST for the file. If the file exists on the floppy, then PIP will print a line containing the directory information for that file, preceeded by the date if it has been entered into the system, and followed by the total number of files on the floppy and the number of free (unused) blocks on it. The number of free blocks can be divided by 6 to find approximately how many more patient data files can be stored on it. If the requested filename does not exist on the floppy, then only the date, total number of files on the floppy, and number of free blocks will be printed. Therefore, this is also an easy way of determining how many files and

how much unused space is on a floppy.

C. Deleting Files

To delete a single file which has erroneous or useless information on it, run PIP, put the floppy in DX1 (the right hand disk slot), and type:

*DX1:name.DAT/D<CR>

where "name" is the filename that you want to delete. This can be repeated for several files, if desired. Be sure that the filename is entered correctly here, because a different file could be inadvertantly deleted if the incorrect file name is typed in.

D. Renaming a File

If a test has been run and it is later discovered that an incorrect filename was used throughout, then it can be renamed, without changing any of the data stored in it, by running PIP, inserting the floppy into DX1, and typing:

*DX1:newname.DAT=DX1:oldname.DAT/R<CR>

where "newname" is the new filename under which you want the data to be stored, and "oldname" is the old filename that was previously used. For example:

*DX1:T01000.DAT=DX1:T00900.DAT/R<CR>

will cause the filename for file T00900.DAT to be changed to T01000.DAT, and the old filename will no longer exist.

Of course, if there was previously still another, earlier, data file stored under filename T00900.DAT and then PRETEST was run again for a different test, and if the same filename was mistakenly entered for a new subject, then the new file can be renamed, but the old data on the first subject would have been deleted and overwritten when T00900.DAT was entered the second time for the new subject. Therefore,

be careful when entering filenames, whether you are running PIP, PRETEST, STRESS, OR REPORT.

E. Copying Data Files (Making Disk Backups)

Data files may be copied from one floppy to another very easily using PIP. This enables one or more backup copies to be made of all important data.

To copy all files from one floppy disk to another, run PIP and do the following:

1. When PIP types "*" to let you know it is ready, remove the system floppy from DX0 (the left hand slot) and replace it with either a new floppy or one which contains no useful data.

2. Type:

   *DX0:/Z<CR>

   as described above under "A. Initializing a Floppy Disk". Note that this will destroy any information stored on DX0, so be sure you have removed the system floppy and replaced it with one which does not have any data that you want to save.

3. When PIP asks:

   DX0:/Z ARE YOU SURE?

   Type Y<CR>

   The floppy in DX0 is now ready to have data copied onto it.

4. Insert the floppy that contains the data files you wish to copy into DX1 (the right hand slot). Several options are now available depending on what you want to do.

   (a) To copy all files from DX1 to DX0, type:

   DX0:.*=DX1:*.*/X<CR>

Note that the first "*" is the one typed by PIP, as usual. This process can take from several seconds to several minutes, depending on how many files are being copied. When PIP has finished, it will type "*" again to let you know it is ready for a new command, such as getting a directory listing.

(b) To copy only those files with the current date (which were created or last modified today), type:

DX0:.*=DX1:*.*/X/C<CR>

The /C causes PIP to compare the dates of each file in the disk directory with the current date entered previously with the DAT command. Therefore, the current date must have been entered correctly when the computer was powered up in order for this to work properly.

(c) To selectively copy certain files, type:

DX0:.*=DX1:*.*/X/Q<CR>

The /Q causes PIP to individually list each filename on DX1 to see if it is to be copied. To bypass copying a particular file, simply hit <CR> (return) after the filename is printed. For files that you do want to copy, type Y<CR> (Y for yes) after their names. For example, if DX1 has files named A.DAT, B.DAT, and C.DAT on it and you want to copy only A.DAT and C.DAT, do the following (your responses are underlined, as usual):

Type *DX0:*.*=DX1:*.*/X/Q<CR>

A	.DAT?Y<CR>	(yes, copy it)
B	.DAT?<CR>	(no, do not copy it)
C	.DAT?Y<CR>	(yes, copy it)

The copying is not actually performed until after you have responded for the last filename on DX1, so if you make a mistake, you can start over by skipping down to the section below called "Terminating PIP", then running PIP again and giving it the desired commands.

(d) To copy only one or a few files, type:

DX0:.*=DX1:name.DAT/X CR

Where "name" is the filename. This can be repeated for several files, if desired.

5. A backup system floppy can be created in a similar manner. First, run PIP and perform steps (1), (2), and (3) above. Next, put the system floppy into DX1 (not its normal location), and type:

DX0:.*=DX1:*.*/X/Y CR

*DX0:A=DX1:MONITR.SYS/U CR

DX0 now contains a floppy which has all of the files that the original system floppy had on it. Note that the copying caused by the first line above may take a minute or two to perform, so wait until it is finished and PIP responds with another "*" before typing the second line.

6. These procedures can be used regularly to maintain backup copies of all data files. The recommended procedure is:

(a) First, perform steps (1), (2), and (3) above.

(b) Second, perform step (4) (a) to copy all files onto a new backup floppy.

(c) Third, perform step (4) (b) at the end of each day to copy new files onto the backup floppy. As an alternative, the new files from one or more days may be copied using the procedures in steps (4) (c) or (4) (d).

It is probably best to keep two backup floppies, in addition to the original, for important data files, since it takes only a few minutes to perform the copying operation.

If you try to copy a data file from one floppy onto another that already contains a file with the same name, then the file on the floppy being copied onto will be deleted and the copy operation will be performed as requested. Normally, this is not really a problem, since files with the same name should generally be identical but if an erroneous filename was entered in PRETEST, for example, then it is possible that this file might replace one on the backup floppy unintentionally. This could happen if the file was copied before correcting the filename using the Rename command (step D above). Therefore, be particularly careful when entering filenames or copying files with possibly erroneous filenames, since valuable data might be deleted.

F. Terminating PIP

When you have finished all of the operations you desire with PIP, the program can be stopped by doing the following:

(1) Wait until PIP has typed "*" to inform you that it has finished its last operation.

(2) Remove the floppy in DX0 if it is not the system floppy disk. Replace it with the system floppy.

(3) Type Control-C (CNTRL-C) to stop PIP and return control of the computer to the monitor so that other commands can be issued, such as running other programs. (if there is not a system floppy in DX0 when Control-C is typed, the system will have to be rebooted). When PIP has been successfully terminated and control has returned to the monitor, the monitor will type a period to inform you it is ready.

PRETEST

This section instructs the user in the application of the CDAS program PRETEST, which allows the user to enter into the computer the essential information concerning a test subject.

1. The user activates the program PRETEST by typing: RUN PRETEST<CR>
2. The computer responds with the message: PATIENT FILENAME: NAME <CR>
   - A. The user must type in the filename to be associated with the subject.
   - (1) NAME can be one to six alphanumeric characters in length.
   - (2) NAME must begin with an alpha character.
     - (a) Examples:

       NAME1 acceptable

       1NAME not acceptable

       NAMEONE not acceptable; too many characters
     - (b) Normally, the unique test number (beginning with a letter) is used.
   - B. If the filename cannot be created on the disk (DX1:) an error message is printed.
     - (1) The error message is: FILE ALLOCATION FAILURE
     - (2) The program PRETEST is terminated.
     - (3) The user must restart (step 1).
     - (4) The error is because:
       - (a) The FILENAME already exists.
       - (b) The FILENAME is incorrectly formated (step 2,A).
       - (c) The disk is full. Two options are then available:
         - (1) Delete old file(s) using PIP.
         - (2) Use a new floppy disk. (See PIP).
   - C. Be sure to enter the correct filename. If you accidentally type in the name of a file containing useful data that should be saved, then interrupt PRETEST by typing Control-C (Control works like Shift). Otherwise, when PRETEST finishes, it will write the new data you have stored out to the floppy disk, thereby destroying all information previously stored under that filename.

3. Once the filename is created on the disk (DX1:) the program prompts the message:

PRETEST QUESTIONS

A. Each question is prompted one at a time.

(1) The user types in the corresponding information.

(a) Each question specifies the format the user response is expected to be entered under.

(b) Be sure to type the data using the exact format specified in parentheses. For example, exactly 2 digits must be entered for the day of the month when the date is entered, so a leading zero must be typed for the first 9 days of the month:
5-SEP-78 is incorrect
05-SEP-78 is correct.

B. The last question prompted by the program is:
ALL INFORMATION CORRECT? (Y=YES)

(1) If the user types a Y the program is terminated.

(2) Any other response and the message:
TYPE QUESTION NUMBER OF INCORRECT ENTRY is printed.

(a) The user can alter any question by typing in the appropriate number of the question to be changed.
NUM <CR>

(3) This sequence of events can be executed repeatedly until a Y response is typed for question B.

STRESS

This section explains the use of program STRESS for conducting an exercise stress test. Once this program is started, all user commands are issued through the control panel push buttons. STRESS can only accept commands from buttons that are illuminated. A steady light ON means the designated function is enabled and the button may be pushed if desired. A flashing light means the operation is currently in progress and the computer is collecting analog data for the test. A light that is turned off means that the corresponding command is not allowed at the particular time, and pushing the button will have no effect. All necessary information about the subject and the test (particularly weight, test mode, test type, and ambient temperature and pressure) must have previously been entered with PRETEST.

A. The CDAS program STRESS is activated by typing:

. RUN STRESS < CR >

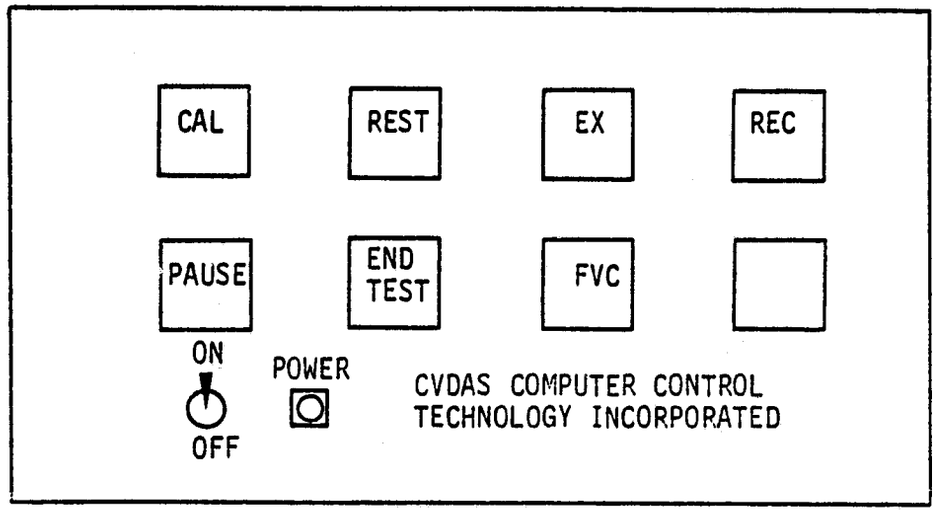
1. PLEASE TYPE PATIENT DATA FILE NAME (UP TO 6 SYMBOLS): NAME <CR>
   (a) The user must enter in the file name.
   (b) The file name is the name associated with the patient's data during the pretest phase.
2. At this point the user should adjust the computer paper so that the printer is at the beginning of a new page.

B. The CDAS control panel is now ready to accept user commands. The use of each pushbutton switch to conduct a test is described below:

1. CAL command pushbutton
   (a) This button is normally the first one pushed for each test. The CAL command instructs the computer program to switch the various analog interfaces to the appropriate modes in order to calibrate the system.
   (b) In order to work properly, the switches on the analog control system should be set to the COMPUTER position so the computer program can control the analog interface. In addition, the mass spectrometer interface should also be set for external computer control, and the calibration gas should be turned on, with the flow set properly.
   (c) Calibration requires about 32 seconds, in which the computer

FIGURE 2

CVDAS CONTROL PANEL



will switch the analog interface to the Low Cal, High Cal, and Ambient calibration modes in sequence and then back to the normal operating mode. During the last four seconds of each of the three calibration modes the CAL button will flash to let the user know that data is being sampled at those times.

(d) A calibration report is then printed on the terminal, listing the calibration factors for each analog channel and the ambient conditions. In addition, appropriate error messages are printed if the calibration routine detects an abnormal condition on one or more channels.

(e) If any of the ambient conditions appear to be erroneous, or if error messages were printed for any analog channel, the calibration should usually be repeated. First, verify that all switches are in their proper positions, the calibration gas is turned on, all cables are plugged in, and that all displays are correct. Then push the CAL button again to repeat the procedure. The calibration can be repeated any number of times, and calibration factors from only the last calibration will be used by the computer program for later calculations. Once the user is satisfied with the calibration, an FVC test or a stress test can be run.

(f) When the computer is ready for calibration from tape, the following three messages are printed:

IS THE TAPE READY FOR LOW CALIBRATION ?? YES OR NO ??

Y<CR>or <N CR>

To proceed, the user must type a "Y" when the analog tape recorder reaches the period where low calibration data was recorded.

IS THE TAPE READY FOR HIGH CALIBRATION ??YES OR NO??

Y<CR>or N<CR>

The user must type in a "Y" to proceed.

IS THE TAPE READY FOR AMBIENT CALIBRATION ? YES OR NO??

Y<CR> or N<CR>

Again, the user must type in a "Y" to proceed.

(g) Following this, on tape playback, the user is requested to enter the time of day from the data recorded on tape (not the actual time of day when the data is being processed). The time should read from the time code generator (reader in the READ mode), with the tape running. Be sure that the time code is continuous on the tape after this point (so that the recorder was not stopped between this time and the actual test start when the data was recorded). Also, do not stop the tape after this on playback until after the test data has all been processed.

2. REST command pushbutton

(a) Following calibration, the REST button may be pushed when a stress test is to be started. As soon as the button is pushed, the computer program initiates acquisition of the analog test data and prints the report header at the top of the printout page.

(b) Data acquisition continues while the header is being printed. However, if respiratory gas analysis is to conducted during rest, the first minute of data should not normally be used, because the exhaled air data is not processed until after the report header is printed, and only 5 seconds of exhaled air data can be stored. This is considerably shorter than the length of time required to print the header. This is not normally a problem, though, since data for other parameters (such as heart rate) can be stored and processed normally, and in most cases respiratory gases are not collected during rest.

(c) While the computer is collecting, storing, and processing data for the rest period, the REST pushbutton/light will flash. After ten minutes, if no other button is pushed, the rest period will be automatically stopped by the computer and it will prepare for the start of the exercise period.

(d) If the rest period is to be shorter than ten minutes, it may be terminated by simply pushing the EXERCISE button

to start the exercise period data collection, or the PAUSE button may be pushed as described below under Paragraph 3.

(e) If the rest period is to be restarted, this may be done at any time after the report header is printed and while the REST light is flashing by simply pushing the REST button again. All previously stored data for the rest period will be eliminated, and the rest period will be restarted at the time the REST button is pushed.

(f) Throughout the rest, exercise, and recovery periods, summary printouts will be printed every 30 seconds. The numbers printed are averages of the previous 30 seconds' data. Blood pressures are checked once per minute, during the 55th second only.

3. PAUSE command pushbutton

(a) The PAUSE button may be pushed if it is desired to temporarily suspend data collection. When pushed, the light currently flashing (for example, the REST light) will stop its flashing and both it and the PAUSE light will be illuminated steadily. In addition, the light for the next pushbutton normally pushed (in this case, EX) will remain on.

(b) Following the pause interval, the current period may be restarted from its beginning by pushing its button (here, REST) to restart it. All previously collected data would be eliminated.

(c) Alternatively, the current period may be continued following the pause interval by simply by pushing the PAUSE button again. In this case the PAUSE light will be turned off, and the light for the current period will begin flashing again to indicate that data collection has resumed. This procedure might be useful if, for example, it was necessary to interrupt the rest period in the middle to replace an ECG electrode or make an adjustment.

(d) As another alternative, the next period may be started following the pause interval by pushing the button for this next test period. In this case both the light for the previously interrupted interval and the PAUSE light will be turned off, and the light for the button that is pushed will start flashing.

4. EX command pushbutton

(a) This button starts data acquisition for the exercise period of the stress test, in a manner similar to the REST button. It only causes a one-line header to be printed at the beginning of the period, rather than the complete report header as at the beginning of rest.

(b) To restart exercise, simply push the EX button again. All previously collected data for exercise will be eliminated and replaced with new data.

(c) The PAUSE button may also be pushed during the exercise period to temporarily suspend data acquisition, as described above under paragraph 3. This may be useful if it is desired to make some adjustments to the ECG electrodes or the mouthpiece/valve/hose assembly. Normally, a pause period in exercise will be ended by pushing the EX button again to restart exercise. However, it is also possible to end the pause interval by pushing the PAUSE button again to continue the exercise period from where it was temporarily stopped, or by pushing the REC button to start recovery.

(d) Usually, the exercise period will be terminated by pushing the REC button, as described below.

(e) Since a maximum of 60 minutes of data can be stored for an entire test, the exercise period is limited in length to the following number of minutes:

60-(number of minutes of Rest + number of minutes desired for Recovery)

If an odd number of half-minute summary lines have been printed for any test period, the effective length of

that period is the next greatest whole number of minutes, because all data stored is for one minute intervals. Time that elapses during pause intervals is not counted in this total, since no data is stored then.

(f) If the rest period is terminated before ten minutes, by pushing the EX button, then any rest data collected after the last 30-second summary line is eliminated. Therefore, only the data printed on the terminal is stored.

5. REC command pushbutton

(a) The REC button may be pushed at any time the EX light is flashing or during a pause interval in exercise to terminate the exercise period and start data acquisition for recovery.

(b) When the REC button is pushed, the EX light will be turned off and the REC light will immediately start flashing, and the current time will be printed in the header for recovery on the summary report. However, data that has been collected since the beginning of the previous 30-second summary printout will be considered part of recovery, rather than exercise, and 30-second reports will continue at the same 30-second intervals as for exercise, and not at every 30-seconds from the time the REC button was pushed. This is done to avoid losing valuable data from the end of exercise or the beginning of recovery. As an example of how this works, assume that the buttons were pushed at the following times:

REST - 08:00:00
EX - 08:12:00
REC - 08:22:10

In this case, the rest period starts at 08:00:00 and ends at 08:10:00, since rest has a maximum length of ten minutes. After a two minute wait, exercise begins at 08:12:00. A short time after the exercise printout at 08:22:00, the REC button is pushed to start recovery.

The program considers the exercise period to have ended at 08:22:00 (not 08:22:10) and recovery to have started also at 08:22:00 (an earlier time than when the REC button was pushed). This prevents the loss of ten seconds of data after 08:22:00. The first recovery summary printout will occur at 08:22:30, which is 30 seconds after the beginning of recovery and not 30 seconds after the time when the REC button was pushed. If one desires to terminate exercise at an even 30-second interval, or during the first 15 seconds thereafter, the REC button can be pushed at any time following the last exercise summary printout. However, if exercise is to be terminated during the last 15 seconds of a 30-second interval, the REC button should normally be pushed following the next printout. In this way, no more than 15 seconds of data, at most, is averaged in with the wrong test section. No data will be lost regardless of when the REC button is pushed.

(c) As discussed above, the maximum amount of data that can be stored for a test is 60 minutes. Therfore, the length of recovery may be limited as mentioned in paragraph 4(e) above.

(d) The PAUSE button may also be used in recovery, as in rest or exercise, although this should not normally be done since data acquisition will be interrupted.

(e) Recovery may also be restarted by pushing the REC button again, although this should not normally be done since previously collected recovery data will be eliminated.

6. END TEST command pushbutton

(a) To terminate the recovery period, push the END TEST button. This causes all test data to be stored on the floppy disk and control of the computer will be returned to the monitor. Other programs can then be run by typing in the appropriate commands at the terminal.

(b) The END TEST button may also be pushed following calibration or a forced vital capacity test (see below) if no stress test is to be run, or if the user notices that the pretest program should be run again to correct some previous data entered.

7. FVC command pushbutton

(a) This button may be pushed following calibration if a forced vital capacity test is to be conducted.

(b) To conduct this test, instruct the subject to inhale as deeply as possible and then exhale as hard and fast as possible, and continue exhaling for as long as he or she can, until all possible air is expelled from the lungs. The subject should be standing when this is done, and may have to repeat it several times if unfamiliar with the procedure. Push the FORCED VITAL CAPACITY button before exhalation starts.

(c) If a FVC does not occur within 10 seconds after the FVC command pushbutton is depressed, the message: FORCED VITAL CAPACITY TEST TIMED OUT PLEASE RETEST SUBJECT is printed on the terminal.

(d) If a FVC breath is less than 1 second in duration the message:
EXPIRATION BREATH TOO SHORT PLEASE RETEST SUBJECT
is printed on the terminal.
In either case (c) or (d), simply reinstruct the test subject and push the FORCED VITAL CAPACITY button again to repeat the test.

(e) Upon a successful acquisition of a forced expiration breath a FVC report is printed on the terminal.

(f) A Forced Vital Capacity test can be executed as many times as the user wants.

(g) Following an FVC test, a stress test can be started by pushing the REST button, or the program can be terminated by pushing the END TEST button.

REPORT

The purpose of this section is to instruct the user in the application of the CDAS program REPORT. This routine performs two distinct functions:

(1) Generates any number of one minute summary reports.

(2) Affords the user the capability to edit the one minute average data.

1. The program REPORT is activated by typing: RUN REPORT<CR>
2. The program responds with the message:
   PLEASE TYPE PATIENT DATA FILENAME (UP TO 6 SYMBOLS): FILENAME<CR>
   A. NAME is the Patient's disk file name that was assigned in the PRETEST program.
   B. NAME must be entered according to the specifications outlined in the PRETEST section.
3. Once the patient's data file is read into the computer from the disk the program prints: VERIFY CORRECT SUBJECT READ IN
   S.S. NUM NNN-NN-NNNN UNIQUE NO. AANNNN RETEST NO. NNNN CPID NO. NN TEST TYPE N
   IS THIS THE CORRECT SUBJECT FILE?? YES OR NO?? Y<CR> or N<CR>
   A. A Y<CR> response instructs the program to continue with normal execution.
   B. A N<CR> response instructs the program to retype the message in stap 2.
4. After the correct subject data is read into the computer the program asks the question: EDITOR REQUIRED ?? YES OR NO? Y<CR> or N<CR>
   A. A N<CR response instructs the program to skip the edit routine and proceed with the one minute summary report(s). (See 5 below)
   B. If the response is Y<CR> the program allows the test data to be edited.
      (1) Once the EDIT subroutine is activated it prints the message:
          SELECT SECTION TO BE EDITED
          1 - REST
          2 - EXERCISE
          3 - RECOVERY
          TYPE IN THE NUMBER OF THE SECTION TO BE EDITED N<CR>
      (a) The editor allows the user to edit any one of the 3 sections and can be repeated as many times as needed.

(b) A single <CR> response instructs the edit subroutine to terminate and proceed with the one minute summary report(s).

(2) Depending upon which section was selcted to be edited the following message is printed.

TYPE IN THE NUMBER(S) OF THE MINUTE(S) TO BE EDITED
MINUTE N <CR>
MINUTE N <CR>
MINUTE <CR>

(a) One or all of the minutes for each section can be edited.

(b) Minutes can be entered in any order.

(c) A single <CR> response terminates the minute entry algorithm.

(3) The edit subroutine allows the user to change the values for each minute average data selected by the following format.

*** SECTION {REST / EXERCISE / RECOVERY} MINUTE NN

HEART RATE Y <CR> OR <CR>
SYSTOLIC BLOOD PRESSURE
DIASTOLIC BLOOD PRESSURE
WORK LOAD OR ELEvATION
RESPIRATORY RATE
OXYGEN CONSUMPTION
CARBON DIOXIDE PRODUCTION
MINUTE VOLUME
SPEED MPH/RPM

(a) This sequence is followed for each minute selected to be edited.

(b) To change a value for any one of the variables the user must respond to the appropriate prompt with a Y <CR> , following the label of the parameter to be changed.

Example:

HEART RATE <CR> (no changes in heart rate)
SYSTOLIC BLOOD PRESSURE Y <CR> } (change SBP from 120 to 125
OLD = 120 NEW = 125 <CR> } for this minute)

(c) Each time a variable is designated to be changed the subroutine prints the old value and accepts the new value.

(d) A single <CR> response indicates no change is to be made in that parameter.

(4) Once all selected minutes are edited, program control returns to Step 4.B.(1).

(5) The user next enters the number of copies desired in response to the message:
HOW MANY COPIES OF REPORT NEEDED? N <CR>

(6) The last computer/user interaction is the instruction:
PLEASE ALIGN TOP OF NEW PAGE WITH PRINTER HEAD
TYPE A "RETURN" WHEN READY <CR>

(7) At this point the program generates the number of one minute reports requested then terminates.

PLOT

In this section the user is instructed in the application of the CDAS program PLOT, which allows the user to select from several choices of data combinations which can be displayed in plot form on the hard copy terminal.

1. The user activates the program by typing:

   . RUN PLOT <CR>

2. Next the computer prints:

   PLEASE TYPE PATIENT DATA FILE NAME (UP TO 6 SYMBOLS): filename <CR>

   The user must enter the file name associated with the test subject which was created by the PRETEST program. If the user enters a file name which cannot be found on the floppy, the computer prints:

   STOP -- FILE ALLOCATION FAILURE

   and the program terminates. The user must restart the program at step 1.

3. The computer prints the choices of plots and asks the user to make a selection:

   0--NO PLOTS (STOP)
   1--REGULAR 4 PLOTS
   2--MIN. VOL. VS TIME
   3--RESP. RATE VS TIME
   4--VO2 VS TIME (ML/KG-MIN)
   5--VO2 VS WL
   6--HR VS WL
   7--SBP VS WL
   8--SBP VS HR
   9--SBP VS VO2
   10--VCO2 VS VO2
   11--MIN. VOL. VS VO2
   12--MIN. VOL. VS VCO2

   MAKE A SELECTION--n<CR>

   The user must enter a number from zero through 12 corresponding to the plot desired.

   A. If the user enters a zero or simply hits the RETURN key the program terminates with:

      STOP--

   B. If the user enters a one, the computer prints:

      HOW MANY COPIES DO YOU WANT?-- n<CR>

      The user responds with the number of times he wants the computer to print the regular four plots.

      It then prints:

      ALIGN NEW PAGE WITH PRINT HEAD. HIT RETURN KEY TO PROCEED. <CR>

      The user must position the print head to the first line of a sheet of paper and press the return key.

H2

On the first page the systolic and diastolic blood pressure vs time are plotted on the left hand plot, and heart rate vs time is plotted on the right hand plot. On the second page the volume of oxygen and volume of carbon dioxide are plotted on the left hand plot. The right hand plot varies. It is work load vs time for ergometer data and volume of oxygen in ml/kg-min vs time for treadmill data.
After plotting the desired number of copies the computer returns to the beginning of step 3.

C. If the user enters a selection from 2 through 12, the computer prints
MAKE A SECOND SELECTION--n ⟨ CR ⟩
Since the computer always prints two plots per page, a second selection must be made in order to continue. The second selection must be from two through twelve and can be the same as the first selection.
The computer next prints:
HOW MANY COPIES DO YOU WANT?--n ⟨ CR ⟩
The user responds with the number of pages he wants printed of the two plots.
The computer asks for page alignment so that the plots will be centered on a sheet of printout paper.
ALIGN NEW PAGE WITH PRINT HEAD. HIT RETURN KEY TO PROCEED. ⟨CR⟩
The user must position the print head to the first line of a sheet of paper and press the return key.
After plotting the desired number of copies the computer returns to the beginning of step 3.

EDICON

In this section the application of the CDAS program EDICON is discussed. This program is an edit algorithm, which allows the user to change any of the calibration constants used by the CDAS program CAL. This is accomplished by changing the calibration constants in the disk file CALCON.DAT.

1. The program EDICON is activated by typing RUN EDICON<CR>
2. The program responds with the message:
   LIST OF CURRENT VALUED NEEDED ?? YES OR NO?? Y<CR> OR N<CR>
   A. A current list of the calibration constants is printed if the answer is yes. Y<CR>
   B. If the response to this question is N<CR> the list is not printed and the computer prompts the message:
      TYPE IN NUMBER OF WORD TO EDIT N<CR>
      Where n is any integer number between 1 and 22.
      See Figure 3 for a list of what each word is.
3. In response to the number the user entered, the program prints
   WORD N) OLD = XXXX.XX NEW =
   This informs the user that
   (1) Which word (constant) that is to be changed
   (2) What the old value is
   (3) Ready to accept the new value NEW = XXXX.XX <CR>

   If an error is made in entering a number or the wrong number is changed, the user may go back and put the previous or a different correct number in any word in this file.

NOTE: If any calibration constants are changed using EDICON, be sure to change the same constants on all backup system floppy disks. Otherwise, an incorrect calibration (possibly with no error indication) would occur if a backup floppy was used later.

FIGURE 3

CALCON . DAT Contents
(Calibration Reference Constants in file CALCON . DAT)

Word No.	Description	Typical Value
1	Spirometer Volume-High Cal. Ref.	8.00ℓ
2	Spirometer Volume-Low Cal. Ref.	0.00ℓ
3	Oxygen-High Cal. (Cal. Gas %)	13.72%
4	Oxygen-Low Cal.	0.00%
5	Nitrogen-High Cal. (Cal. Gas %)	81.50%
6	Nitrogen-Low Cal.	0.00%
7	Carbon Dioxide-High Cal. (Cal. Gas %)	4.78%
8	Carbon Dioxide-Low Cal.	0.00
9	Heart Rate-High Cal.	180.bpm
10	Heart Rate-Low Cal.	60.00bpm
11	Ergometer Work Load-High Cal	240.00watts
12	Ergometer Work Load-Low Cal.	60.00watts
13	Treadmill Elevation-High Cal.	32.00%
14	Treadmill Elevation-Low Cal.	8.00%
15	Ergometer Pedal Speed-High Cal.	80.00rpm
16	Ergometer Pedal Speed-Low Cal.	20.00RPM
17	Treadmill Belt Speed-High Cal.	8.00mph
18	Treadmill Belt Speed-Low Cal.	2.00mph
19	Systolic Blood Pressure-High Cal.	200.00mmHg
20	Systolic Blood Pressure-Low Cal.	50.00mmHg
21	Diastolic Blood Pressure-High	200.00mmHg
22	Diastolic Blood Pressure-Low	50.00mmHg

APPENDIX A

TROUBLE SHOOTING CHART

TROUBLESHOOTING CHART

This chart is intended to serve as a quick reference guide to help direct the user of the system to a solution for any of a variety of problems. Since there are an extremely large number of specific failure modes of a system this complex, it is impossible to list every specific problem that might occur. However, with this chart and a good understanding of the system operation, it should be possible for the cause of most problems to be located fairly quickly so that the proper corrective actions can be taken. It is essential that the user have a good understanding of the entire system so that (1)problems will be recognized as such when they occur, and (2)appropriate action can immediately be taken when a problem does occur so that the trouble area can be isolated and identified. Therefore, it is assumed that the user of the system and of this troubleshooting chart is completely familiar with this entire manual and all details of system operation. With these points in mind, the following should be helpful both as a checklist and as a general guide to someone experiencing troubles with the system. For further information, please refer to the appropriate manuals for the microcomputer equipment.

NOTE: Before checking any of the following specific points, verify that all switches and controls are in their proper positions and that all information has been entered into the computer properly. Experience has shown that over 75% of all problems experienced are related to incorrect switch placement or data entry.

IF YOU OBSERVE THE FOLLOWING PROBLEM:	CHECK THE FOLLOWING & TAKE THE APPROPRIATE CORRECTIVE ACTION:
1. Terminal does not print	° Check all switches & indicators on terminal. ° Verify proper operation in local mode. If O.K. in local, go on-line and check baud rate, and items under number 2 below. If improper operation in local, check terminal power, fuses, or for other failures in the terminal.

2. System does not boot properly.	° Check power indicator lights to verify all units are plugged in, turned on, fuses are O.K., etc. ° Check system floppy disk for: proper insertion, floppy drive door closed, not write protected. Try backup system floppy. ° Check terminal as in Number 1 above. ° Verify HALT/ENABLE switch is in ENABLE position. ° Try the manual re-boot ("RUN") switch. ° Check operation of: computer power supply; CPU, memory, disk interface, SMU, and serial interface circuit boards.
3. System does not respond properly to TIM and DAT commands.	° LTC switch should be on. ° Try re-booting the system. ° Check items under Number 2 above
4. Error messages are printed on terminal:	
° Input Conversion Error	• Re-enter number in proper format.
° File Allocation Failure	◦ Check for: illegal or incorrect file-name, insufficient free space on floppy, floppy write protected.
° Calibration Out of Range:	° Check channel identification and magnitude of calibration error.
° O_2, N_2, or CO_2	° Verify mass spectrometer and cal gas are turned on, mass spectrometer and interface control switches are set properly, and cables are plugged in.
° Heart Rate	° Check for proper operation of cardiotachometer.
° Other Channels	° Check for hardware problem in the analog interface or analog output cables. If error is only a few percent, and O_2, N_2, and CO_2 are all O.K., then a hardware recalibration may be required but testing can continue with limited accuracy in the affected channels.

° All Channels	° Check Real Time-Playback switches, and tape recorder if in playback mode. Also check if proper timesfor each calibration interval are being used, if in playback mode. ° Verify that mode switch on analog interface is in computer position.
5. No response occurs from pushbutton switches.	° Verify all information requested by computer was entered properly. ° Only lighted switches are operable. ° LTC switch should be on. ° Tap each switch to ensure that none are stuck. ° Check parallel interface and control panel, cable, and connections.
6. Printed test data is incorrect.	° Check calibration report for any error messages or abnormal ambient conditions. ° Determine which channels are in error to pinpoint which data is incorrect.
° Incorrect blood pressures on part of printout.	° Manual B.P. override switch left on with no updated B.P.'s being entered. ° Blood pressure system inflation or computer system clock not synchronized properly with time code generator-reader.
° Incorrect work load, elevation, or speed.	° Bicycle/treadmill switch left in wrong position or cables disconnected. ° All values should be 0 during Rest and Recovery.
7. Other problems with program STRESS only.	° Check all analog signals, cables, and laboratory instrumentation. ° Check analog-to-digital converter, real-time clock, and parallel interface circuit boards.

8. Other problems with any program.	° Check computer power supply, AC line voltage and condition, etc. ° Check computer circuit boards and floppy disk drive as in Number 2 above. ° Verify that proper patient data file-name was entered.

APPENDIX B

SAMPLE HARD COPY OUTPUT

```
RT-11SJ    V02C-02

.DAT 20-DEC-79

.TIM 10:32:15

.DAT
20-DEC-79

.TIM
10:32:20

.RUN PRETEST

PATIENT FILENAME :E0555

            PRETEST QUESTIONS
1. SUBJECT NAME: [redacted]

2. SUBJECT SEX(M=MALE,F=FEMALE): M

3. SOCIAL SEC. NO.(NNN NN NNNN)
111 11 1111

4. DATE OF BIRTH (DD-MMM-YY):
[redacted]

5. HEIGHT (CM): 187.0

6. WEIGHT (KG) :60.6

7. TEST DATE (DD-MMM-YY):
20-DEC-79

AGE: [redacted]
8. UNIQUE NO.(AANNNN):
E0555

9. RETEST NO.: 1

10. CPID NO.(NNN):
555

11. TEST MODE:(1=LIVE,2=TAPE) 1

12. TYPE OF TEST : (2=TREADMILL,1=ERGOMETER) 2

13. AMBIENT TEMP.(C) : 21.8

14. AMBIENT PRESSURE(MMHG): 765.2

ALL INFORMATION CORRECT ? (Y=YES)
N

TYPE QUESTION NUMBER OF INCORRECT ENTRY
6

6. WEIGHT (KG) :68.6

ALL INFORMATION CORRECT ? (Y=YES)
Y

STOP --
```

```
.RUN STRESS

  PLEASE TYPE PATIENT DATA FILE NAME (UP TO 6 SYMBOLS):EO555

                                CALIBRATION REPORT
                                CDAS - V2.0

  CPID NO.:     555                              UNIQUE NO.: EO 555

  RETEST NO.:   1                                DATE:       20 DEC 79

  SUBJECT NAME: [redacted]                       SEX:        M

  SOC. SEC. NO.: 111-11-1111

  AMBIENT CONDITIONS:                            CALIBRATION FACTORS:

                                                 CHANNEL     SLOPE      Y-INT.
  TEMP.:        21.8 C                           SP.VOL      0.00249      5.009
  PRES.:        765.2 MM HG                      O2          0.00498      9.651
  STPD FACTOR:  0.909                            N2          0.02566     49.591
  BTPS FACTOR:  1.052                            CO2         0.00529     10.300
  O2:           16.2%                            HR          0.07223    145.720
  N2:           80.5%                            ELEV/WL     0.01015     19.870
  CO2:          0.20%                            SPEED       0.00255      4.969
                                                 SBP         0.06320    124.160
                                                 DBP         0.06308    124.232

  OXYGEN   CALIB. OUT OF RANGE BY  -83.4%

  NITROGEN CALIB. OUT OF RANGE BY    4.7%

  CO2      CALIB. OUT OF RANGE BY  111.8%
```

CALIBRATION REPORT
CDAS - V2.0

CPID NO.: 555 UNIQUE NO.: EO 555

RETEST NO.: 1 DATE: 20 DEC 79

SUBJECT NAME: [redacted] SEX: M

SOC. SEC. NO.: 111-11-1111

AMBIENT CONDITIONS:

TEMP.:	21.8 C
PRES.:	765.2 MM HG
STPD FACTOR:	0.909
BTPS FACTOR:	1.052
O2:	20.6%
N2:	79.0%
CO2:	0.08%

CALIBRATION FACTORS:

CHANNEL	SLOPE	Y-INT.
SP.VOL	0.00249	5.009
O2	0.00634	12.233
N2	0.02513	48.653
CO2	0.00251	4.858
HR	0.07218	145.763
ELEV/WL	0.01015	19.872
SPEED	0.00255	4.969
SBP	0.06321	124.153
DBP	0.06307	124.227

EXERCISE RESPONSE TEST: TREADMILL
JSC CARDIOPULMONARY LABORATORY
30 SECOND SUMMARY

CPID NO: 555 SS NO: 111-11-1111 DATE OF TEST: 20 DEC 79 UNIQUE NO: EO 555
START TIME OF TEST: 10:45: 0 WEIGHT(KG) : 68.6 AGE (YRS) : [redacted]

MIN AVG	HR BPM	SBP MM HG	DBP MM HG	ELEV % GRD	SPEED MPH	VO2 L/MN	VO2 ML/KG/MN	VCO2 L/MIN	M VOL L/MIN	RER	RESP RATE	MV/VO2	MV/VCO2	VO2/HR ML/BEAT
* * * * REST * * * *						REAL TIME: 10:45:00								
	78	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
1	84	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	79	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
2	65	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	73	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
3	77	108	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	74	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
4	76	119	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	75	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
5	81	113	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	78	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
6	82	101	60	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	78	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
7	71	125	73	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	82	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
8	81	117	78	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	81	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
9	97	107	75	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
	121	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
10	83	124	80	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
* * * EXERCISE * * *						REAL TIME: 10:56:00								
	98	0	0	9.8	1.5	0.43	6.2	0.37	17.5	0.86	10	41.0	47.7	4.4
1	94	136	69	9.8	1.5	0.73	10.6	0.60	19.2	0.82	12	26.4	32.3	7.8
	101	0	0	9.8	1.5	0.76	11.1	0.58	16.5	0.76	10	21.5	28.3	7.5
2	100	144	65	9.8	1.5	0.81	11.8	0.59	15.7	0.73	12	19.3	26.7	8.1
	96	0	0	9.8	1.5	1.13	16.5	0.82	21.0	0.72	12	18.5	25.7	11.8
3	98	135	68	10.3	1.6	1.06	15.3	0.79	19.5	0.74	12	18.4	24.8	10.8
	104	0	0	11.8	2.4	1.24	18.1	0.96	23.8	0.77	14	19.2	24.9	11.9
4	112	145	62	11.8	2.5	1.24	18.0	0.98	23.9	0.79	14	19.3	24.4	11.1
	117	0	0	11.8	2.5	1.35	19.7	1.12	27.3	0.83	18	20.2	24.5	11.5
5	117	150	65	11.8	2.5	1.61	23.5	1.43	34.4	0.89	20	21.4	24.0	13.8
	120	0	0	11.8	2.5	1.38	20.1	1.26	29.9	0.92	14	21.7	23.7	11.5
6	124	151	67	11.8	2.5	1.59	23.1	1.49	34.9	0.94	20	22.0	23.4	12.8
	132	0	0	13.7	3.3	1.69	24.7	1.63	39.2	0.97	22	23.2	24.0	12.8
7	145	177	59	13.7	3.3	1.86	27.0	1.86	45.1	1.00	22	24.3	24.2	12.8
	156	0	0	13.7	3.3	2.03	29.6	2.19	50.9	1.08	22	25.0	23.3	13.0
8	161	198	58	13.7	3.3	2.09	30.4	2.34	55.4	1.12	26	26.5	23.7	12.9
	168	0	0	13.7	3.3	2.25	32.8	2.58	62.9	1.14	26	27.9	24.4	13.4
9	174	201	59	13.7	3.3	2.12	30.8	2.55	65.4	1.20	28	30.9	25.7	12.1
	182	0	0	15.9	4.1	2.40	34.9	2.91	81.1	1.21	34	33.8	27.9	13.1
10	188	197	0	16.0	4.1	2.50	36.4	3.23	94.1	1.29	38	37.6	29.1	13.3
* * * RECOVERY * * *						REAL TIME: 11:06:07								
	182	0	0	0.0	0.0	2.18	31.8	2.92	83.1	1.34	34	38.0	28.4	12.0
1	170	212	50	0.0	0.0	1.88	27.4	2.60	74.6	1.38	32	39.7	28.7	11.1
	157	0	0	0.0	0.0	1.24	18.1	2.07	63.0	1.66	28	50.7	30.5	7.9
2	147	217	61	0.0	0.0	0.98	14.4	1.68	53.2	1.71	26	54.0	31.6	6.7

	135	0	0	0.0	0.0	0.73	10.7	1.20	41.8	1.64	22	56.9	34.8	5.4
3	131	101	60	0.0	0.0	0.70	10.2	1.06	37.1	1.51	22	52.8	35.0	5.4
	121	0	0	0.0	0.0	0.62	9.1	0.89	32.5	1.43	20	52.0	36.4	5.1
4	119	101	60	0.0	0.0	0.35	5.0	0.48	18.1	1.39	16	52.1	37.6	2.9
	116	0	0	0.0	0.0	0.48	7.0	0.56	20.2	1.16	18	41.9	36.1	4.2
5	109	174	55	0.0	0.0	0.61	8.9	0.65	22.6	1.07	14	37.2	34.8	5.6
	106	0	0	0.0	0.0	0.51	7.5	0.57	20.1	1.11	16	39.1	35.2	4.9
6	106	134	72	0.0	0.0	0.39	5.7	0.45	16.9	1.14	16	42.9	37.8	3.7
	102	0	0	0.0	0.0	0.42	6.1	0.46	17.0	1.09	16	40.7	37.2	4.1
7	103	128	69	0.0	0.0	0.37	5.4	0.39	14.5	1.05	12	39.3	37.4	3.6
	101	0	0	0.0	0.0	0.35	5.2	0.36	13.4	1.03	12	37.7	36.8	3.5
8	102	115	68	0.0	0.0	0.37	5.4	0.38	13.7	1.01	10	36.8	36.6	3.7

STOP --

.RUN REPORT

PLEASE TYPE PATIENT DATA FILE NAME (UP TO 6 SYMBOLS):EO555

VERIFY CORRECT SUBJECT DATA READ FROM DISK

S.S. NUM. 111-11-1111 UNIQUE NO. EO 555 RETEST NO. 1 CPID NO. 555 TEST DATE 12/20/79 TEST TYPE 2

IS THIS THE CORRECT SUBJECT FILE ?? YES OR NO ?? Y

EDITOR REQUIRED ?? YES OR NO ?? N

HOW MANY COPIES OF REPORT NEEDED ? 2

PLEASE ALIGN TOP OF NEW PAGE WITH PRINTER HEAD
TYPE A "RETURN" WHEN READY

EXERCISE RESPONSE TEST: TREADMILL

~~JSG CARDIOPULMONARY LABORATORY~~

ONE MINUTE SUMMARY

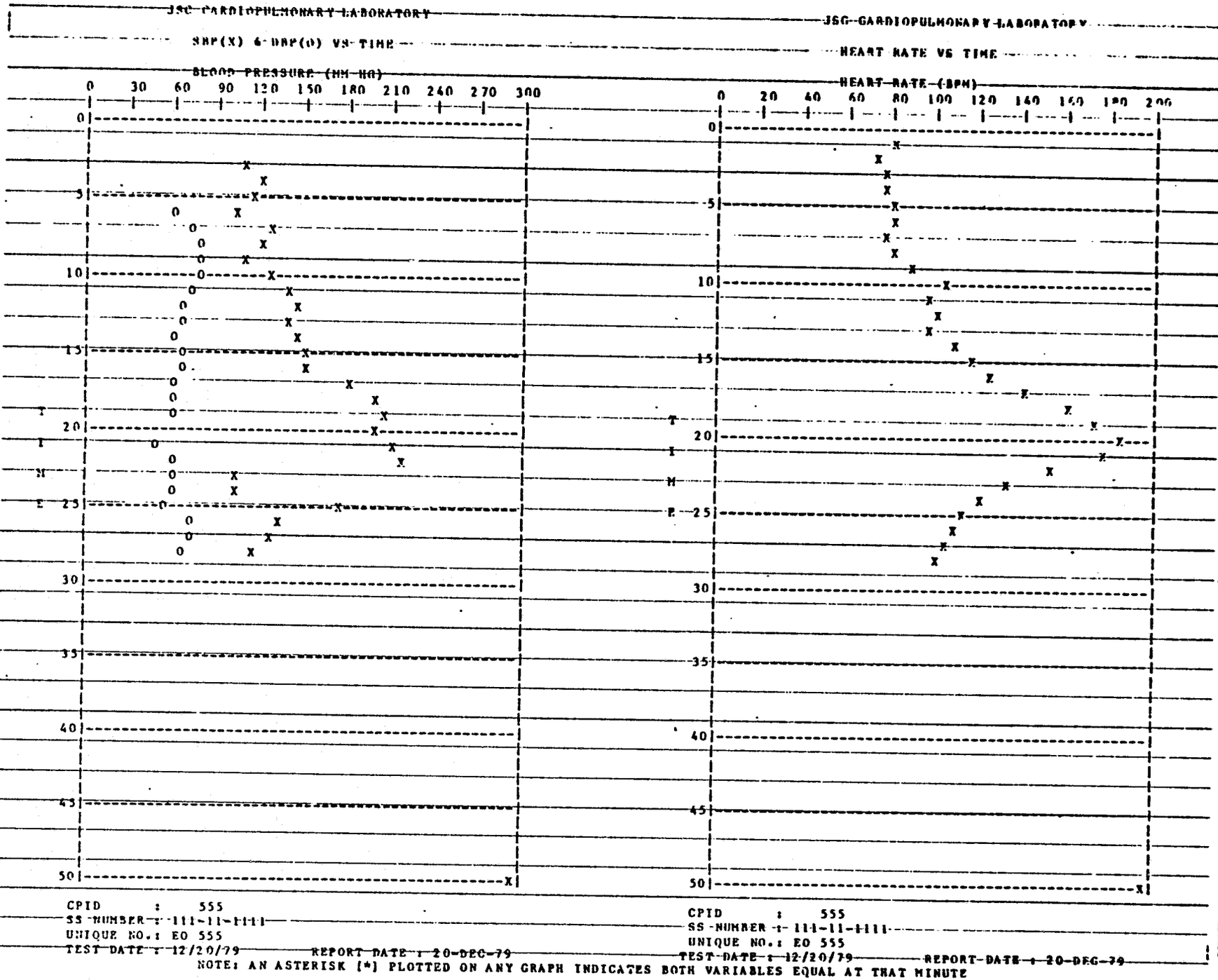
CPID NO 555 SS NO. 111-11-1111 DATE OF TEST 12/ 20/ 79 UNIQUE NO EO 555

START TIME OF TEST: 10:45: 0 WEIGHT (KG) : 68.6 AGE (YRS) : [redacted] WORK LOAD SUM 0

MIN AVG	HR BPM	SBP MM HG	DBP MM HG	ELEV % GRD	SPEED MPH	VO2 L/MN	VO2 ML/KG/MN	VCO2 L/MIN	M VOL L/MIN	RER	RESP RATE	MV/VO2	MV/VCO2	VO2/HR ML/BEAT
* * * REST * * * REAL TIME: 10:45: 0														
1	81	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
2	72	0	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
3	75	108	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
4	75	119	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
5	78	113	0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
6	80	101	60	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
7	74	125	73	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
8	81	117	78	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
9	89	107	75	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
10	102	124	80	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0	0.0	0.0	0.0
* * * EXERCISE * * * REAL TIME: 10:56: 0														
1	96	136	69	9.8	1.5	0.58	8.4	0.48	18.4	0.83	11	31.8	38.2	6.0
2	100	144	65	9.8	1.5	0.79	11.5	0.58	16.1	0.74	11	20.4	27.5	7.9
3	97	135	68	10.0	1.6	1.10	16.0	0.80	20.2	0.73	12	18.5	25.2	11.3
4	108	145	62	11.8	2.5	1.24	18.1	0.97	23.9	0.78	14	19.3	24.7	11.5
5	117	150	65	11.8	2.5	1.48	21.6	1.27	30.9	0.86	19	20.8	24.2	12.7
6	122	151	67	11.8	2.5	1.48	21.6	1.38	32.4	0.93	17	21.9	23.5	12.1
7	138	177	59	13.7	3.3	1.77	25.9	1.75	42.2	0.99	22	23.8	24.1	12.9
8	158	198	58	13.7	3.3	2.06	30.0	2.26	53.1	1.10	24	25.8	23.5	13.0
9	171	201	59	13.7	3.3	2.18	31.8	2.56	64.1	1.17	27	29.4	25.0	12.8
10	185	197	0	15.9	4.1	2.45	35.7	3.07	87.6	1.25	36	35.8	28.6	13.2
* * * RECOVERY * * * REAL TIME: 11: 6: 7														
1	176	212	50	0.0	0.0	2.03	29.6	2.76	78.8	1.36	33	38.8	28.6	11.5
2	152	217	61	0.0	0.0	1.11	16.2	1.87	58.1	1.68	27	52.1	31.0	7.3
3	133	101	60	0.0	0.0	0.72	10.5	1.13	39.4	1.57	22	54.9	34.9	5.4
4	120	101	80	0.0	0.0	0.49	7.1	0.69	25.3	1.42	18	52.1	36.9	4.0
5	112	174	55	0.0	0.0	0.55	7.9	0.60	21.4	1.11	16	39.2	35.4	4.9
6	106	134	72	0.0	0.0	0.45	6.6	0.51	18.5	1.12	16	40.8	36.4	4.3
7	102	128	69	0.0	0.0	0.39	5.7	0.42	15.7	1.07	14	40.0	37.3	3.9
8	101	115	68	0.0	0.0	0.36	5.3	0.37	13.6	1.01	11	37.2	36.7	3.6

REPORT DATE 20-DEC-79

```
STOP --
.RUN PLOT

  PLEASE TYPE PATIENT DATA FILE NAME (UP TO 6 SYMBOLS):E0555

 0--NO PLOTS (STOP)            7--SBP VS WL
 1--REGULAR 4 PLOTS            8--SBP VS HR
 2--MIN. VOL. VS TIME          9--SBP VS VO2
 3--RESP. RATE VS TIME         10--VCO2 VS VO2
 4--VO2 VS TIME(ML/KG-MIN)     11--MIN. VOL. VS VO2
 5--VO2 VS WL                  12--MIN. VOL. VS VCO2
 6--HR VS WL

MAKE A SELECTION--1

HOW MANY COPIES DO YOU WANT?--1

ALIGN NEW PAGE WITH PRINT HEAD.  HIT RETURN KEY TO PROCEED.
```

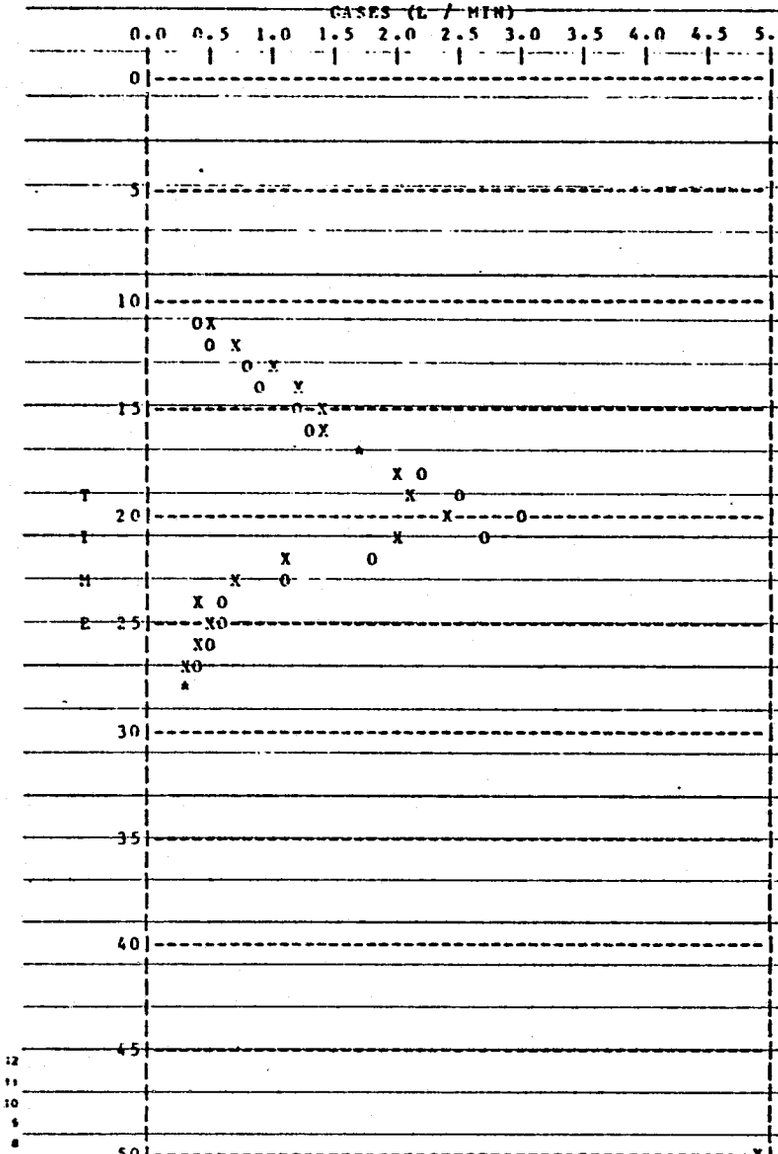


NOTE: AN ASTERISK (*) PLOTTED ON ANY GRAPH INDICATES BOTH VARIABLES EQUAL AT THAT MINUTE

JSC CARDIOPULMONARY LABORATORY

VO2(X) & VCO2(O) VS TIME

CASES (L / MIN)

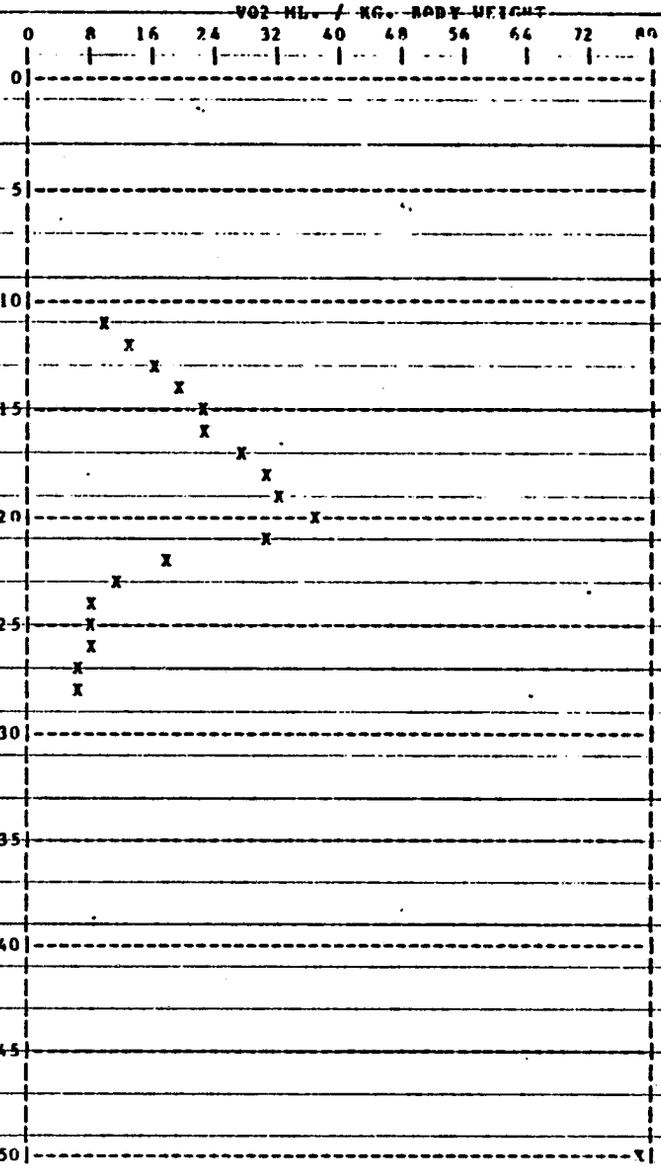


CPID : 555
SS NUMBER : 111-11-1111
UNIQUE NO.: EO 555
TEST DATE : 12/20/79 REPORT DATE : 20-DEC-79

JSC CARDIOPULMONARY LABORATORY

VO2 ML/KG VS TIME

VO2 ML. / KG. BODY WEIGHT



CPID : 555
SS NUMBER : 111-11-1111
UNIQUE NO.: EO 555
TEST DATE : 12/20/79 REPORT DATE : 20-DEC-79

NOTE: AN ASTERISK [*] PLOTTED ON ANY GRAPH INDICATES BOTH VARIABLES EQUAL AT THAT MINUTE

```
.RUN EDICON

 LIST OF CURRENT VALUES NEEDED  ?? YES OR NO ??N

 TYPE IN NUMBER OF WORD TO EDIT 3

  WORD    3 )   OLD =       14.52      NEW = 13.71

 TYPE IN NUMBER OF WORD TO EDIT 5

  WORD    5 )   OLD =       81.90      NEW = 81.51

 TYPE IN NUMBER OF WORD TO EDIT 7

  WORD    7 )   OLD =       4.58       NEW = 4.78

 TYPE IN NUMBER OF WORD TO EDIT
STOP --
```

APPENDIX C

EQUATIONS USED IN THE SOFTWARE

EQUATIONS

A. CALIBRATION ROUTINE - CAL

1. Vapor pressure of water at atmospheric pressure and temperature.

$$PH_2O = .0369 \times AMBTEMP^2 - .4012 \times AMBTEMP + 10.76$$

2. STPD factor to adjust volume at ambient conditions to volume at standard temperature and pressure (Dry).

$$STPD = (273.16/(AMBTEMP + 273.16)) * ((AMBPRES - PH_2O)/760.)$$

3. BTPS factor to convert minute volume from ATPS to body temp. (310°K.)

$$BTPS = 310.0/(AMBTEMP + 273.0)$$

B. FORCED VITAL CAPACITY ROUTINE - PFT

1. Predicted forced vital capacity

Males: PFVC = 0.06584 x Height - 0.02954 x Age - 5.12451

Females: PFVC = 0.04071 x Height - 0.02147 x Age - 2.56958

2. Predicted forced expiratory flow at one second

Males: PFEV1 = 0.0425 x Height - 0.03509 x Age - 2.59946

Females: PFEV1 = 0.0407 x Height - 0.02147 x Age - 2.56958

Height is in cm.

Reference: By: Reuben M. Cherniack, M.D.

In: Pulmonary Function Testing, W.B. Saunders, pp. 243, 1977.

3. Forced Vital Capacity

$$FVC = ((\sum_{JPK-11}^{JPK-1} GASBUF/10) * SLOPE + YINRCP) * BTPS$$

4. Forced Expiratory volume at 1 second

$$FEV1 = (GASBUF(100) \times SLOPE + YINTRCP) \times BTPS$$

5. Peak expiratory flow rate

TAN = ((GASBUF + 4) = GASBUF)/0.04

get max tangent value

PEFR = (TAN x SLOPE + YNTRCP) x BTBS

6. Forced expiratory flow between 25% and 75% max FVC

FEF + ((GASBUF 75% - GASBUF 25%) x SLOPE)/TIME 75% - TIME 25%) *BTPS

7. Forced expiratory flow between 200 ml and 1200 ml.

FEF + (((GASBUF1200 - GASBUF 200) x SLOPE)/(TIME 1200 - TIME 200))

*BTPS

C. EXERCISE ROUTINE - EX

1. Work load adjustment

$WL_{new} = WL_{old} + .25$ (Target HR - PRESENT HR)

2. Oxygen consumed in one 30 seconds

VO2 = VO2 + STPD x ($_2$AMB x (N_2OUT/N_2AMB) x VOLOUT - O_2OUT x VOLOUT)

3. Carbon Dioxide produced

VCO2=VCO2 + STPD x (CO_2OUT x VOLOUT - CO_2AMB x (N_2OUT/N_2AMB)xVOLOUT)

APPENDIX D

A/D SAMPLING SPECIFICATIONS

And CHANNEL ASSIGNMENTS

Channel Number	Mnemonic	A/D Input Signal	Sampling Rate	Conditions and Comments
0	SPVOL	Spirometer Displacement (Volume)	100 H_Z	Sampled continuously, but stored only during exhalation
1	O_2	Oxygen Concentration	100 H_Z	Not sampled during FVC. Otherwise, same as SPVOL.
2	N_2	Nitrogen Concentration	100 H_Z	
3	CO_2	Carbon Dioxide Concentration	100 H_Z	
4	HR	Heart Rate	10 H_Z	Sampled continuously, but samples for instantaneous heart rates less than 35 are not averaged.
5	WL/ELEV	Bicycle Ergometer work load or treadmill elevation	10 H_Z	
6	SPEED	Pedal speed or walking speed	10 H_Z	
7	SBP	Systolic Blood Pressure	10 H_Z	Sampled only during the 55th second of each minute.
8	DBP	Diastolic Blood Pressure	10 H_Z	

APPENDIX E

Notes on Operation of CDAS from Tape Playback

OPERATION OF CDAS FROM TAPE PLAYBACK

Using CDAS during playback is very similar to operation during a real-time test, but the following points must be kept in mind:

(1) The computer system clock (set by using the TIM command) must be synchronized with the time being played back from the analog tape. Otherwise, incorrect times and blood pressures will be printed on the computer output. Also remember that the tape must be running in playback continuously after the computer system clock is set. If the tape has to be stopped or rewound, the computer clock must be reset with the TIM command.

(2) All buttons on the control panel (except for CAL) must be pushed at the times they normally would be pushed during a real-time test. In other words, if the test recorded on tape had a Rest start time of 09:00:00, then the START/STOP button should be pushed precisely when the time code reader displays that time as it is read from the tape. However, the CAL button should be pushed at least 10 seconds before the actual start of the manual calibration data recorded on tape, because there has to be time for the computer to ask the operator if the tape is ready for low cal before it actually starts. It is always good practice to turn on the strip chart recorder before calibration and to monitor it during the entire interval that the computer is sampling. The data on the tape should not change to the next interval (from low to high cal, for example) until after the computer has finished sampling and asks if the tape data is ready for the next calibration interval. If the tape data displayed on the strip chart does change before the computer prints the message asking about the next interval (or before the calibration report is printed following ambient air calibration), then the entire calibration process must be repeated. There is less chance

that this might happen if at least 20 seconds of data is recorded on the tape for each interval during the manual calibration procedure before the test is started. Also, when you are doing a calibration during playback, be sure not to use the automatic computer calibration times for the real-time test, because those calibration intervals are too short to use during playback. It is a good idea only to write down the manual calibration start times on the analog tape log sheet and not the computer calibration start times.

(3) In addition to the manual calibration start times on the tape log sheet, this sheet should also have all the information necessary to run the test from playback. That way the Exercise Data Sheet with the heart rates, blood pressures, etc., is only needed if data editing is required when running program "Report". Be sure to put the test date, ambient temperature, barometric pressure, room air concentrations, etc., on the tape log sheet before the test is run, so that later, if the test data needs to be processed from tape playback, then all of that information will be available. The test date and ambient conditions recorded on the log sheet (which are the conditions during the actual test) should be used in program Pretest rather than conditions of the room the time the playback is done. The ambient gas concentrations should be checked on the playback computer calibration report to make sure that they are within about 0.1% of the values on the tape log sheet. (CO_2 should be within 0.05%). Anything out of the ordinary that happened during the test and which might affect the data recorded on the tape should be noted on the tape log sheet under "comments" so that the computer printout can later be checked for possible problems. For example, if the mouthpiece slips out of the subject's mouth for a few seconds during exercise or if the cardiotachometer reads erroneous heart rates due to excessive noise on the ECG, write it down on the log sheet so that the data can be corrected

or zeroed out later. Any suspicious functioning of any of the lab instrumentation should also be noted here, so that if a problem is discovered later, it can be isolated and resolved quickly, and so that we will have a record of which tests might be affected. Be as specific as possible - for example, say "Blood pressure cuff did not inflate from 09:20:00 to 09:23:30" if that's what happened. Don't just say "Blood pressure machine didn't work".

(4) Be sure to look over the computer printout carefully during the playback run and when finished. If a partial printout is available from the same test in real time, compare them. If all information was entered correctly and all buttons were pushed at the proper times for both computer runs, then the data should be very similar. Even if a partial real-time printout is not available, check to make sure that the treadmill elevation and speed change on the printout at the proper times. This will help to verify that the start/stop button was pushed at about the right time (at least for the start of exercise) and that the times were logged correctly. Also check all of the other data to make sure that they are reasonable for each stage of the test, including rest and recovery.

(5) Remember that the same patient filename used in program Pretest must be used when running program Stress. However, if you erroneously give the computer a file name which has previously been used and which has data that you want to save, then the old file will be deleted and replaced with the new data when the program ends. This unpleasant event can be avoided while you are running Pretest if you realize that you have entered an incorrect patient file name. Just use a control-C (CNTR-C) at any time before the end of the Pretest questions (or even when it asks if any of the entries need to be corrected) in order to abort the program. A Control-C will require you to restart Pretest from the beginning but will prevent anything from being written out to the floppy disk file.

A similar thing can be done during program Stress if you realize that you have erroneously given the computer the filename of a previous test whose data you want to save. Use two control-C commands (don't push END TEST) to abort Stress without having anything written out to the floppy disk. Of course, if you went all the way through Pretest with a filename which is incorrect, then it is already too late to save the previous data.

The main things to remember are these:

(a) When Pretest or Stress finish, they will write out any data they have to the floppy disk, and it will be stored under the filename you have given.

(b) Only one file with a particular filename can be stored on a single floppy disk. If you give the computer the name of a file that already exists, then it will be deleted and replaced with the new data when the program finishes execution. This is done deliberately so that if a file has erroneous data on it then the file can be corrected easily by running the program again. That way there will not be a problem of using the wrong data file for a particular test, since normally only one such file can be stored.

(c) If for some reason you want to store two files with information from the same test, you must either use a different floppy disk for the second patient data file (be sure to label each accordingly), or else use a different filename. For example, if you have a partial run that was recorded in real-time and which you want to save, but you also want to run the same data through the computer again in playback, then you can do this: Leave the first file as it is, for real-time data. To create another, separate, file for playback, put a P or some other letter at the end of the unique test number and use the combination as the playback filename, for Pretest, Stress, and Report and Plot if used.

(d) Only the first 6 characters of the filename you specify are used by the computer. Therefore, filenames T1234 and T1234P can be used to access two different files, but filenames T01234 and T01234P will be considered the same by the computer since the P in the second filename is the 7th letter and is therefore ignored. Therefore, be sure to always use filenames of 6 characters or less if you want the computer to be able to store them uniquely.